

CLAIMS

- [c1] 1. A ballistic-resistant laminate assembly, comprising:
a first layer having a plurality of ballistic-resistant fiber strands positioned adjacent to each other, a plurality of first bonding strips and a plurality of second bonding strips, the first bonding strips being spaced apart from each other by a selected distance, being connected to the fiber strands and being positioned at a first angle relative to the fiber strands, the second bonding strips being spaced apart from each other by a selected distance, being positioned at a second angle relative to the fiber strands, and being cross-plyed with the first bonding strips;
a first laminate film positioned on one side of the fiber strands and bonded with the first or second bonding strips to the first layer; and
a second laminate film positioned adjacent to a side of the fiber strands opposite the first laminate film.
- [c2] 2. The assembly of claim 1 wherein the fiber strands are high-performance fibers having a tensile strength of at least 9 grams/denier.
- [c3] 3. The assembly of claim 1 wherein the first bonding strips are ballistic-resistant bonding fibers coated with an adhesive material.
- [c4] 4. The assembly of claim 1 wherein the first and second bonding strips are arranged in a woven pattern.
- [c5] 5. The assembly of claim 1 wherein the second bonding strips are ballistic-resistant bonding fibers coated with an adhesive material.

- [c6] 6. The assembly of claim 1 wherein the second bonding strips include high aramid fibers coated with an adhesive material.
- [c7] 7. The assembly of claim 1 wherein the second laminate film is bonded to the first layer, with the fiber strands being laminated between the first and second laminate films.
- [c8] 8. The assembly of claim 1 wherein the fiber strands are first fiber strands, and further comprising a second layer having a plurality of ballistic-resistant second fiber strands positioned adjacent to each other, and a plurality of third bonding strips spaced apart from each other by a selected distance and connected to the second fiber strands, the third bonding strips being positioned at a third angle relative to the second fiber strands, the second fiber strands being cross-plyed relative to the first fiber strands.
- [c9] 9. The assembly of claim 8 wherein the first and second fiber strands are bonded to each other with at least one of the first, second, or third bonding strips.
- [c10] 10. The assembly of claim 8 wherein the first and second layers are positioned immediately adjacent to each other between the first and second laminate films.
- [c11] 11. The assembly of claim 8 wherein one of the first and second laminate films is between the first and second layers.
- [c12] 12. The assembly of claim 8 wherein one of the first and second laminate films is between the first and second layers, and further comprising a third laminate film positioned adjacent to the second layer opposite one of the first and second laminate films.

[c13] 13. The assembly of claim 8 wherein the first layer is between the first and second laminate films to form a first laminated layer, and further comprising third and fourth laminated layers with the second layer therebetween forming a second laminated layer adjacent to the first laminated layer.

[c14] 14. A ballistic-resistant laminate assembly, comprising:
a plurality of ballistic-resistant fiber strands;
first bonding fibers spaced apart from each other and interconnecting the fiber strands, the first bonding fibers being oriented at a predetermined angle relative to the fiber strands; and
second bonding fibers spaced apart from each other and connected to the fiber strands and being at a predetermined angle relative to the first bonding fibers, least the first or second bonding fibers being ballistic-resistant fibers coated with a pressure or heat-sensitive adhesive material, the first and second bonding fibers forming a bi-directional array of bonding fibers that hold the fiber strands in a substantially parallel orientation.

[c15] 15. The assembly of claim 14 wherein the first bonding fibers are interspersed within the fiber strands.

[c16] 16. The assembly of claim 14 wherein the first and second bonding fibers are arranged in a substantially woven pattern.

[c17] 17. The assembly of claim 14 wherein the first and second bonding fibers are aramid fibers coated with an adhesive material.

[c18] 18. The assembly of claim 14, further comprising a first laminate film adjacent to one side of the fiber strands and bonded to at least one of the first or second bonding fibers, and a second laminate film, the fiber strands and the array

of bonding fibers being laminated and substantially sealed between the first and second laminate films with interstitial air pockets therebetween to form a laminated ballistic-resistant assembly with positive buoyancy.

[c19] 19. The assembly of claim 14 wherein the fiber strands are first fiber strands, the array of bonding fibers is a first array of bonding fibers, and the first fiber strands and first array of bonding fibers form a first layer, and further comprising a plurality of ballistic-resistant second fiber strands positioned adjacent to each other, and a bi-directional second array of bonding fibers spaced apart from each other and interconnecting the second fiber strands to form a second layer cross-plyed with the first layer.

[c20] 20. The assembly of claim 19 wherein the first and second layers are immediately adjacent to each other.

[c21] 21. The assembly of claim 19 further comprising a first laminate film is between the first and second layers.

[c22] 22. The assembly of claim 19, further comprising first, second, and third laminate films, the first layer being between the first and second laminate films, and the second layer being between the second and third laminate films.

[c23] 23. The assembly of claim 19 wherein one of the first bonding fibers is substantially aligned with the first fiber strands and has a first color different from a color of the fiber strands, and at least one of the second bonding fibers is substantially aligned with the second fiber strands and has a second color different from the first color and different from a color of the second fiber strands, the first and second colors providing a visual indication of the orientation of the first and second fiber strands relative to each other.

[c24] 24. The assembly of claim 14 wherein the fiber strands, the array of bonding fibers and the laminate film are laminated together and form a flexible ballistic-resistant panel.

[c25] 25. The assembly of claim 14 wherein the fiber strands, the array of bonding fibers and the laminate film are laminated together and form a rigid ballistic-resistant panel.

[c26] 26. A ballistic-resistant laminate assembly, comprising:
a first layer having ballistic-resistant first fiber strands positioned adjacent to each other, a plurality of first bonding fibers and a plurality of second bonding fibers, the first bonding fibers being spaced apart from each other by a selected distance and being positioned at a predetermined angle relative to the first fiber strands, and the second bonding fibers being spaced apart from each other by a selected distance and being cross-plyed with the first bonding fibers;
a first laminate film positioned on one side of the first layer;
a second laminate film on a side of the first layer opposite the first laminate film;
a second layer having ballistic-resistant second fiber strands positioned adjacent to each other, a plurality of third bonding fibers, and a plurality of fourth bonding fibers, the third bonding fibers being spaced apart from each other by a selected distance and being positioned at a predetermined angle relative to the second fiber strands, and the third bonding fibers being spaced apart from each other by a selected distance and being cross-plyed with the fourth bonding fibers, the second laminate film being between the first and second layers; and
a third laminate film positioned on a side of the second layer opposite the second laminate film.

- [c27] 27. The assembly of claim 26, further comprising a fourth laminate film positioned between the second laminate film and the second layer.
- [c28] 28. The assembly of claim 26 wherein the first, second, third, or fourth bonding fibers are ballistic-resistant fibers coated with an adhesive material.
- [c29] 29. The assembly of claim 26 wherein the first, second, third, or fourth bonding fibers are aramid fibers coated with a pressure or heat-sensitive adhesive material.
- [c30] 30. The assembly of claim 26 wherein the first fiber strands are aramid fibers.
- [c31] 31. The assembly of claim 26 wherein the first layer is substantially sealably laminated between the first and second laminate films with interstitial air pockets therebetween forming a laminated layer with positive buoyancy.
- [c32] 32. The assembly of claim 26 wherein the second bonding fibers are substantially parallel to the first fiber strands, and the first bonding fibers are substantially perpendicular to the second bonding fibers.
- [c33] 33. The assembly of claim 26 wherein the first and second bonding fibers are arranged in a woven pattern.
- [c34] 34. The assembly of claim 26 wherein one of the first bonding fibers is substantially aligned with the first fiber strands and has a first color different from a color of the first fiber strands, and at least one of the third bonding fibers is substantially aligned with the second fiber strands and has a second color different from the first color and different from a color of the second fiber strands,

the first and second colors providing a visual indication of the orientation of the first and second fiber strands relative to each other.

- [c35] 35. A ballistic-resistant laminate assembly, comprising:
- a substantially planar first layer having a plurality of first fiber strands positioned adjacent to each other, and a plurality of bonding fibers spaced apart from each other by a selected distance and connected to the first fiber strands, the bonding fibers being positioned at a predetermined angle relative to the first fiber strands, the first layer having generally opposing first and second surfaces;
 - a first laminate film adhered to the first surface of the first layer;
 - a second laminate film adhered to the second surface of the first layer, the first and second laminate films sandwiching the first layer therebetween forming a first laminated ballistic-resistant sheet with the first fiber strands in a substantially parallel orientation;
 - a substantially planar second layer having a plurality of second fiber strands positioned adjacent to each other, the second layer having generally opposing third and fourth surfaces, the third surface being adhered to the second laminate film; and
 - a third laminate film adhered to the fourth surface of the second layer, the second and third laminate films sandwiching the second layer therebetween forming a second laminated ballistic-resistant sheet connected to the first laminated ballistic-resistant sheet with the second fiber strands in a substantially parallel orientation.

- [c36] 36. The assembly of claim 35 wherein the first and second fiber strands are aramid fibers.

- [c37] 37. The assembly of claim 35 wherein the bonding fibers and the first fiber strands are arranged in a substantially woven pattern.

[c38] 38. The assembly of claim 35 wherein the bonding fibers in the first layer are substantially perpendicular to the first fiber strands.

[c39] 39. The assembly of claim 35 wherein the first fiber strands are cross-plied at a selected angle relative to the second fiber strands.

[c40] 40. The assembly of claim 35 wherein the first layer is substantially sealed between the first and second laminate films with first interstitial air pockets therein and the second layer is substantially sealed between the second and third laminate films with second interstitial air pockets therein, the first and second air pockets providing the assembly with a positive buoyancy.

[c41] 41. A flexible, multiple-layer ballistic-resistant panel comprising:
a flexible first laminated sheet including a plurality of first fiber strands positioned substantially parallel to each other and forming generally opposing first and second surfaces, a plurality of spaced-apart first bonding fibers connected to the first fiber strands and positioned at an angle relative to the first fiber strands, and a first laminate film adhered to the first surface of the first fiber strands forming first interstitial airspaces therein;
a flexible second laminated sheet positioned immediately adjacent to the first laminate sheet having a plurality of second fiber strands positioned substantially parallel to each other and forming generally opposing third and fourth surfaces, a plurality of spaced-apart second bonding fibers connected to the second fiber strands and positioned at an angle relative to the second fiber strands, and a second laminate film adhered to the third surface of the second fiber strands forming second interstitial air spaces therein; and

a joining member securely retaining the first and second fiber strand laminated sheets together forming a laminated structure with positive buoyancy.

[c42] 42. The ballistic-resistant panel of claim 41 wherein the first fiber strands are cross-plied at a selected angle with the second fiber strands.

[c43] 43. The ballistic-resistant panel of claim 42 wherein the first fiber strands are aramid fibers.

[c44] 44. The ballistic-resistant panel of claim 41 wherein the first and second bonding fibers include ballistic-resistant fibers.

[c45] 45. A ballistic-resistant laminate assembly, comprising:
a substantially planar first layer having a plurality of ballistic-resistant first fiber strands positioned adjacent to each other and a plurality of ballistic-resistant bonding fibers spaced apart from each other and connected to the first fiber strands, the bonding fibers being coated with an adhesive material and being positioned at a predetermined angle relative to the first fiber strands;
a first laminate film adhered to the first layer with the first fiber strands in a substantially parallel orientation, the first layer and the first laminate film forming a first laminated ballistic-resistant sheet;
a second layer having a plurality of unidirectional ballistic-resistant second fiber strands positioned adjacent to each other; and
a second laminate film adhered to the second layer with the second fiber strands in a substantially parallel orientation, the second layer and the second laminate film forming a second laminated ballistic-resistant sheet connected to the first laminated ballistic-resistant sheet.

[c46] 46. The assembly of claim 45 wherein the bonding fibers are substantially perpendicular to the first layer's fiber strands.

[c47] 47. The assembly of claim 45 wherein the second laminate film is between the first and second fiber strands.

[c48] 48. The assembly of claim 45, further comprising a third laminate film attached to the first layer sandwiching the first fiber strands between the first and third laminate films forming a first laminated layer, and further comprising a fourth laminate film attached to the second layer sandwiching the second fiber strands between the second and fourth laminate films forming a second laminated layer adjacent to the first laminated layer.

[c49] 49. The assembly of claim 48 wherein the first laminated layer includes substantially sealed interstitial air spaces between the first and third laminate films, and the second laminated layer includes substantially sealed interstitial air spaces between the second and fourth laminate films, the first and second laminated layers having a positive buoyancy.

[c50] 50. The assembly of claim 45 wherein the bonding fibers are aramid fibers coated with a pressure or heat-sensitive adhesive.

[c51] 51. The assembly of claim 45 wherein the bonding fibers are first bonding fibers, and further comprising a plurality of ballistic-resistant second bonding fibers coated with an adhesive material spaced apart from each other and substantially parallel with the second fiber strands, the second bonding fibers being cross-plyed with the first bonding fibers forming an array of bi-directional bonding fibers.

[c52] 52. The assembly of claim 51 wherein the first and second bonding fibers are arranged in a woven pattern.

[c53] 53. The assembly of claim 45 wherein the first and second laminate sheets are flexible sheets joined together to form a flexible, multiple-layer ballistic-resistant panel.

[c54] 54. The assembly of claim 45 wherein the first and second laminate sheets are joined together to form a rigid, multiple-layer ballistic-resistant panel.

[c55] 55. A flexible, multiple-layer ballistic-resistant panel, comprising:
a first flexible, unidirectionally oriented fiber strand laminate sheet including a plurality of unidirectional first fiber strands made of ballistic-resistant fibers positioned substantially parallel to each other, a plurality of spaced-apart first bonding fibers made of a ballistic-resistant material coated with an adhesive and connected to first fiber strands and positioned at an angle relative to the first fiber strands, and a first laminate film adjacent to the first fiber strands; and
a second flexible, unidirectionally oriented fiber strand laminate sheet positioned adjacent to the first flexible, unidirectionally oriented fiber strand laminate sheet and having a plurality of unidirectional second fiber strands made of ballistic-resistant fibers positioned substantially parallel to each other, a plurality of spaced-apart second bonding fibers made of ballistic-resistant fibers coated with an adhesive and connected to the second fiber strands and positioned at an angle relative to the second fiber strands, and a second laminate film adjacent to the second fiber strands.

[c56] 56. The panel of claim 55 wherein the first bonding fibers are substantially perpendicular to the first fiber strands.

[c57] 57. The panel of claim 55 wherein the first bonding fibers and the first fiber strands are made of the same ballistic-resistant material.

[c58] 58. The panel of claim 55 wherein the first unidirectionally oriented fiber strand laminate sheet has third ballistic-resistant bonding fibers coated with an adhesive material and positioned substantially parallel with the first fiber strands and cross-plyed with the first bonding fibers to form an array of bi-directional, ballistic-resistant bonding fibers.

[c59] 59. The panel of claim 58 wherein the second unidirectionally oriented fiber strand laminate sheet has fourth ballistic-resistant bonding fibers coated with an adhesive material and positioned substantially parallel with the second fiber strands and cross-plyed with the second bonding fibers to form a second array of bi-directional, ballistic-resistant bonding fibers.

[c60] 60. A ballistic-resistant laminate assembly, comprising:
a first layer having a plurality of ballistic-resistant fiber strands positioned adjacent to each other, a plurality of first bonding strips and a plurality of second bonding strips, the first bonding strips being spaced apart from each other by a selected distance, being connected to the fiber strands and being positioned at a first angle relative to the fiber strands, the second bonding strips being spaced apart from each other by a selected distance, being positioned at a second angle relative to the fiber strands, and being cross-plyed with the first bonding strips;
a first laminate film positioned on one side of the fiber strands and bonded with the first or second bonding strips to the first layer; and

a second laminate film adjacent to a side of the fiber strands opposite the first laminate film.

[c61] 61. The assembly of claim 60 wherein the fiber strands are high performance fibers having a tensile strength of at least 9 grams/denier.

[c62] 62. The assembly of claim 60 wherein at least one of the first and second bonding strips are bonding fibers.

[c63] 63. The assembly of claim 1 wherein at least one of the first and second bonding strips include ballistic-resistant fibers coated with an adhesive material.